ExxonMobil's Toxic Torrance Refinery Failure, 2015

by

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Abstract

This report discusses the ethicality of ExxonMobil's actions when performing maintenance leading up to the Torrance refinery explosion in 2015. The Torrance refinery was ExxonMobil's second smallest refinery that accounted for over 10% of the gasoline produced throughout California. In addition, this refinery was located in the center of a 150,000 person community, making safety in refinery processes critical in protecting the surrounding community. However, ExxonMobil implemented an unsafe, alternative procedure when performing maintenance on equipment that ultimately led to an explosion. After further investigation, it became evident that the refinery managers had ignored clear signs of danger and had used expired equipment, playing a significant role in the disaster. ExxonMobil violated three of Chevron Phillips' 10 Tenets of Operation in the events leading up to the explosion. The company had hoped to maximize the production of gasoline and company profit when violating these tenets, but the opposite occurred. The violation of several tenets led to the injury of 4 refinery workers, a $566,000 fine from OSHA, a heavy hit to the company stock, and a heavy hit to gasoline prices throughout California. Furthermore, a toxic catalytic dust was released into the surrounding Torrance community that has unknown and potentially devastating, long-term side effects. If ExxonMobil had acted ethically in accordance with the 10 Tenets of Operation, then these problems could have been avoided altogether because ethical actions yield a safer and more profitable work environment.

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Introduction

On February 18th, 2015, ExxonMobil's Torrance refinery managers and operators made a series of poor decisions surrounding equipment maintenance, which led to an explosion (DIR, 2015). The explosion injured four contractors and released a toxic catalytic dust over the surrounding community and environment (DIR, 2015). By using out of date operating equipment, poorly addressing abnormal conditions, and ignoring countless signs of danger, ExxonMobil acted unethically and ultimately prioritized profit over safety. Chevron Phillips' 10 Tenets of Operation will be used as a basis for ethical behavior and they will be used in analyzing ExxonMobil's unethical actions leading up to the refinery explosion.

ExxonMobil's refinery in Torrance, California has been integral in the production of gasoline for California since the General Petroleum Company established the plant in 1928 (CSB, 2017, p.8). Although the Torrance refinery was ExxonMobil's second smallest refinery, it produced over five million gallons of gasoline per day, accounting for over ten percent of the total gasoline sold throughout California (CSB, 2017, p.8). This 750-acre refinery required nearly 1200 workers to operate at full capacity, and was located in the center of a 150,000-person community in Torrance, California as shown in Fig. 1 (CSB, 2017, p.9). In addition to gasoline, the refinery produced lesser volumes of diesel fuel and jet fuel, as well as sulfur and other chemicals (CSB, 2017, p.8).

The main steps of the refinery process and ExxonMobil's changes to the process, causing the explosion, will be analyzed. This report will cover ExxonMobil's unethical actions and how these actions resulted in the technical failures of the Torrance Refinery process. Then, using the 10 Tenets of Operation, ExxonMobil's actions will be critiqued to prove that Exxon acted unethically in the Torrance refinery explosion. Finally, the impacts of the explosion will be further discussed to emphasize the importance of ethical action in refinery processes. However, not every component of the refinery process will be covered in this report, but rather, just the components of the refinery that played a role in the explosion. In addition, only the safety and monetary impacts of the explosion will be analyzed in this report, not governmental, societal, or any other overarching impact.

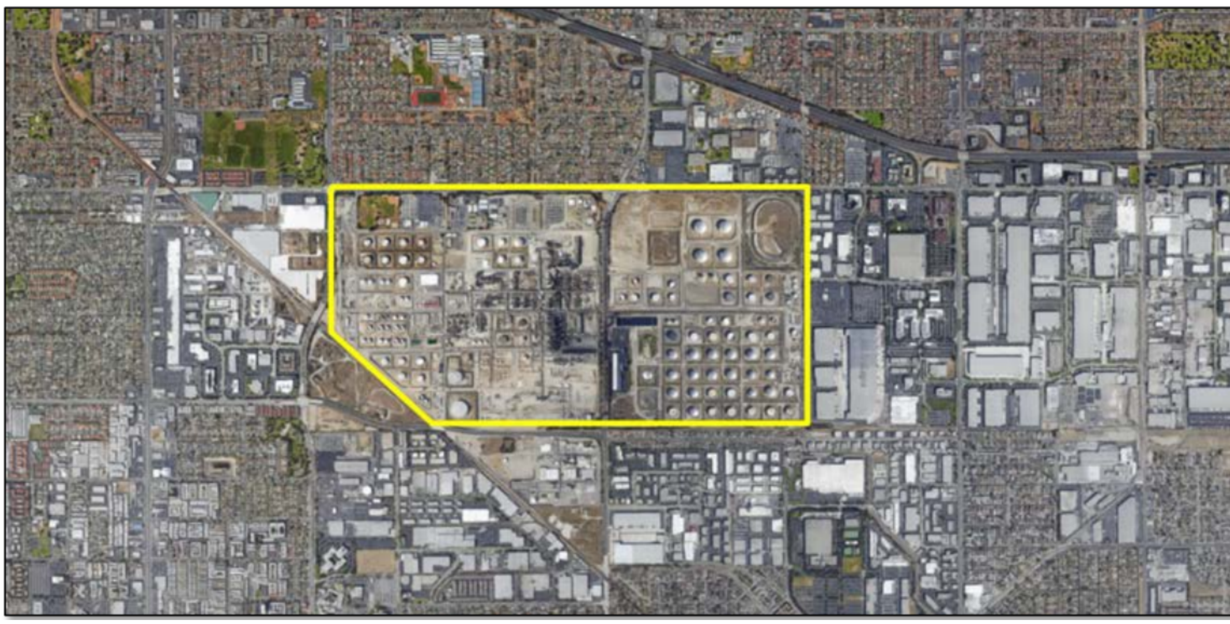

Figure 1. ExxonMobil's Torrance refinery is surrounded by a large community (CSB, 2017, p.9).

The Fluid Catalytic Cracking Unit

The Torrance refinery explosion occurred in the fluid catalytic cracking unit (FCC). The FCC unit breaks or "cracks" higher boiling point hydrocarbon molecules into smaller molecules, which is necessary for hydrocarbons to be used for fuel (CSB, 2017, p.10). At the end of the process, the FCC produces mainly light hydrocarbons and heavy naphtha, which are then further processed into gasoline (CSB, 2017, p.12). The FCC unit itself is divided by valves into two multicomponent sides: the air side and the hydrocarbon side as shown in Fig. 2 (CSB, 2017, p.10). The hydrocarbon side contains the reactor, the main column, and a series of pumps. The air side contains the regenerator and the gas/catalyst separator, as well as the expander, boiler, and the electrostatic precipitator. Hydrocarbons should never enter the air side.

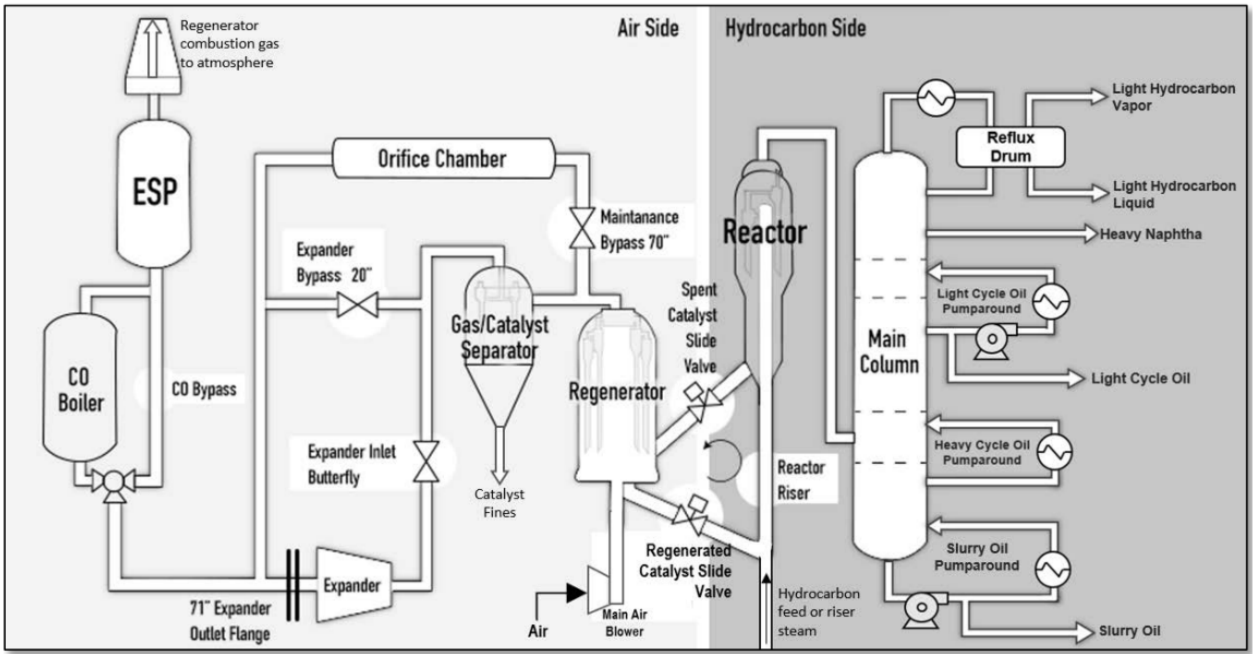

Figure 2. Outline of the Fluid Catalytic Cracking Unit, divided into the air side and the hydrocarbon side (CSB, 2017, p.10).

The Catalyst Loop

At the border between the two sides, a catalyst loop forms between the regenerator and reactor as shown in Fig. 3 (CSB, 2017, p.11). The small, spherical pellets of catalyst are aerated in this loop to ensure they flow throughout the whole system, rather than settling at the bottom of a unit (CSB, 2017, p.11). The heated and aerated catalyst leaves the regenerator and passes through the regenerated catalyst side valve (RCSV) into the reactor (CSB, 2017, p.12). After performing the reaction, the used or "spent" catalyst accumulates a thin coating of one of the solid byproducts from the reaction (CSB, 2017, p.12). Therefore, the spent catalyst must be sent through the spent catalyst side valve (SCSV) and back into the regenerator so the solid coating can be burnt off, allowing the catalyst to be reused. In this burning process, combustion gasses are produced in the regenerator (CSB, 2017, p.13).

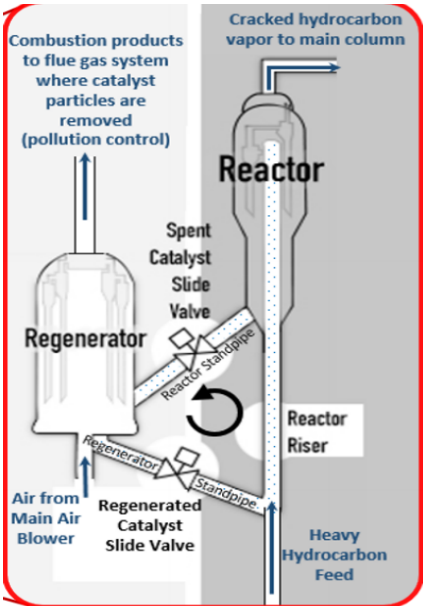

Figure 3. Depiction of the catalyst loop between the regenerator and the reactor (CSB, 2017, p.11).

Combustion Gas

The combustion gas formed during the recycling of catalyst is treated within the FCC, as outlined in Fig. 4 (CSB, 2017, p.13). First, the gas is sent to the gas/catalyst separator which removes the majority of remaining catalytic dust in the gas (CSB, 2017, p.13). This cleaner gas is then sent through the expander, which uses the natural expansion of the gas to power the main air blower so catalyst can be aerated back in the catalyst loop (CSB, 2017, p.13). The combustion gas then enters the carbon monoxide boiler where leftover heat is removed. After removing leftover heat, the combustion gas is fed to the electrostatic precipitator (ESP) where spark-producing charged plates remove any remaining catalytic dust (CSB, 2017, p.13). The gas, now safe by California state regulations, can then safely enter the environment.

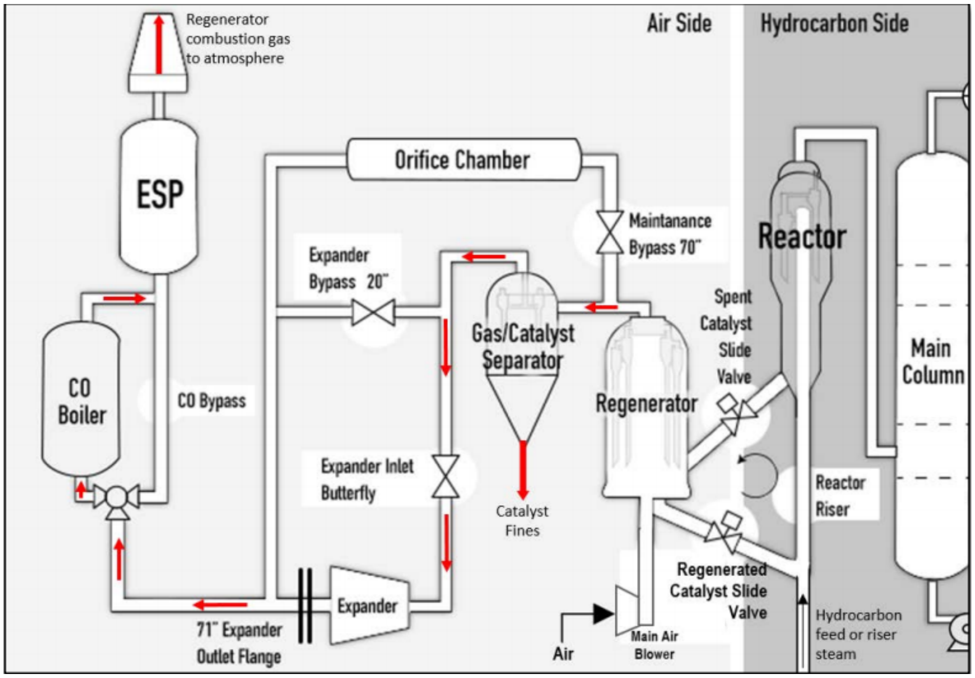

Figure 4. Depiction of cleaning combustion gas process within the FCC unit (CSB, 2017, p.13).

The Main Column

Returning to the other side of the catalyst loop, the catalyst and uncracked hydrocarbons remain in the reactor, while the "cracked" or broken down hydrocarbons leave the reactor so they can be further separated in the main column (CSB, 2017, p.12). In the main column, the hydrocarbon vapor is separated into its different forms by condensation as shown in Fig. 5 (CSB, 2017, p.12). Heat is removed from the vapor in the column by pumping the vapor through pipes that surround other pieces of equipment within the FCC, transferring heat in the process. As the hydrocarbon vapor cools, it condenses into light hydrocarbons and heavy naphtha, cycle oil, and an oil slurry, the final products of the FCC process (CSB, 2017, p.12).

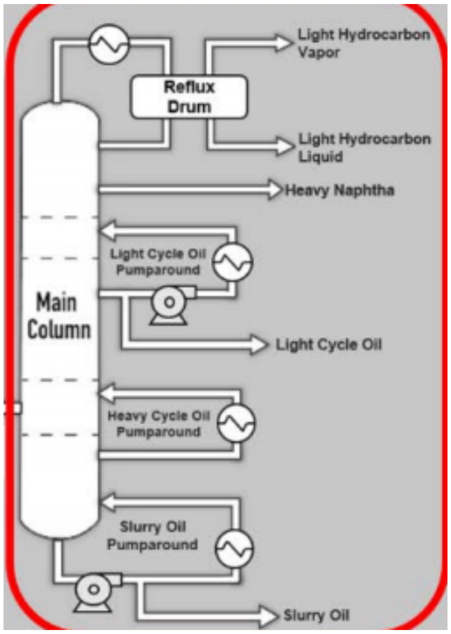

Figure 5. Depiction of the Main Column used to separate hydrocarbon vapor by condensation (CSB, 2017, p.12).

Safe Park Mode

Another integral aspect of the FCC unit is the “Safe Park” mode. Safe Park is a term used by ExxonMobil to define the status of a unit that has taken a series of automatic actions after sensors detect dangerous conditions. Safe Park mode does not fully shut down the system, but rather, the system is left in an emergency idle state where sections of the system remain in operation as shown in Fig. 6 (CSB, 2017, p.17). Although many sections shut down, the main column pumps remain energized, the ESP remains activated, and the hydrocarbons within the system remain in the unit (CSB, 2017, p.16). The disconnect between Safe Park and a full system shutdown results out of a desire to maximize profits. Leaving certain units within the system energized reduces restart time, minimizing gasoline loss. As a result of initiating Safe Park, the air side of the FCC no longer provides an air flow into the hydrocarbon side, so the backflow of hydrocarbons into the sparking ESP is an imminent danger. Therefore, the system enacts automatic safety precautions, including the closure of the SCSV and the RCSV, which blocks any connection between the air side and hydrocarbon side. Additionally, the hydrocarbon feed as well as the main air blower stop, allowing the normally aerated catalyst in the regenerator to settle onto the closed RCSV and the normally aerated catalyst in the reactor to settle onto the closed SCSV (CSB, 2017, p.17). Ultimately, this action helps to further block the only two connection points between the two sides due to catalyst buildup on the valves. Finally, steam valves are opened to allow steam to flow in place of the halted hydrocarbon feed (CSB, 2017, p.17). The steam applies a constant pressure towards any remaining hydrocarbons to prevent backflow into the air side. In summary, the closure of the SCSV and RCSV and the catalyst build up on the valves provide physical barriers to prevent hydrocarbon backflow. Also, the constant pressure from the forward flowing steam helps to further aid this physical barrier. Essentially, two measures are taken to prevent backflow of hydrocarbons: creating a physical barrier and applying pressure.

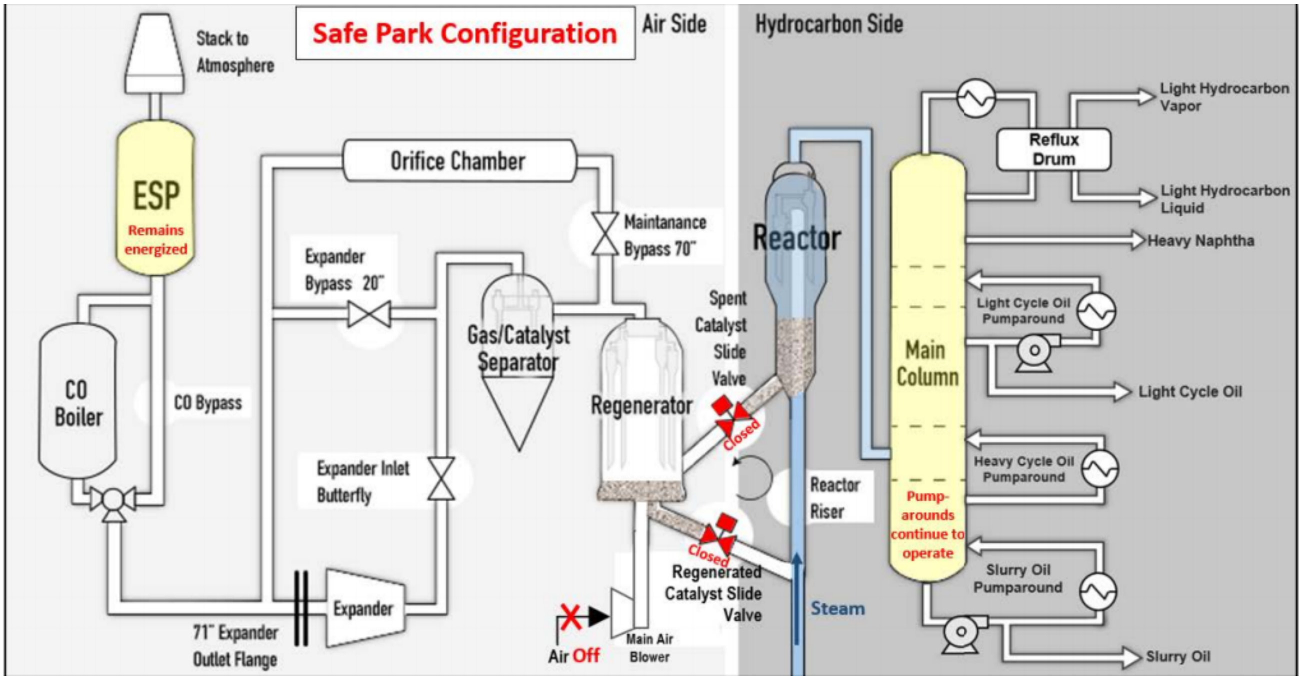

Figure 6. Depiction of Safe Park mode used in the Torrance Refinery, where specifics units cease operation (CSB, 2017, p.17).

The Incident

The FCC began to experience heavy vibrations due to an issue with the expander. Eventually, the vibrations grew so intense that the system automatically entered Safe Park mode. Due to a lack of space, the expander could not be isolated by the traditional methods ExxonMobil had formed for isolating sections of a unit (CSB, 2017, p.18). The management decided to follow a “variance” procedure approved and used in 2012 for a similar situation (CSB, 2017, p.19). After the variance procedure began, the reality of several dangers became apparent due to a steam leak. Rather than halting the process and conducting a safety analysis, the managers of the refinery pressed forward (CSB, 2017, p.19). As a result, the workers were only aware of the imminent danger minutes before the explosion occurred (CSB, 2017, p.21-22).

The Vibrations

The first sign of abnormality came with the FCC unit vibration. Operators expected this to be due to a buildup of solid catalyst on the expander blades, an issue that had been seen before in many similar plants (CSB, 2017, p.18). Because the combustion gas enters the expander before entering the ESP, small amounts of catalytic dust can often accumulate on the blades as the gas passes through the expander (CSB, 2017, p.16). The typical solution to this issue was to simply clean the blades of the expander, then the expander could continue to function normally. This time, however, vibrations reappeared less than a week after cleaning the expander blades, eventually rising to an even higher rate than the original vibrations (CSB, 2017, p.16). After the blades were cleaned a second time, no perceivable reduction of vibrations occurred. In the same day as this second cleaning, vibrations grew violent enough for the FCC unit to enter the "Safe Park" mode (CSB, 2017, p.16).

At this point, management held a meeting to figure out the most efficient way to return the system to full operation. Per ExxonMobil's company regulations, in order to perform maintenance on a section of a unit in Safe Park, the section had to be safely isolated from the process. Due to spatial constraints, it was found that the expander could not be isolated by ExxonMobil's traditional process, which combined the "Double Block and Bleed" and blinding method (CSB, 2017, p.30).

Isolation Methods and the Variance

The Block and Bleed method involves the use of a block valve to stop the flow of process fluid to the piece of equipment that is to be isolated (CSB, 2017, p.26). Then, a bleed valve is placed between the block valve and the semi-isolated section to remove any remaining process fluid. Finally, a pressure gauge is added to ensure correct bleeding and to check for leaks (CSB, 2017, p.26). When the block and bleed method is combined with blinding, "blinds" are placed at the inlet and outlet of the isolated section as well. A blind is simply a disc of metal placed inside of the pipe to physically obstruct any process fluid from entering the isolated area (CSB, 2017, p.26). Claiming that space did not allow for the traditional isolation method of Double Block and Bleed with blinding, the managers decided to follow a "Variance" procedure performed in 2012, that called for a less strict isolation method. A diagram of the traditional Double Block and Bleed isolation method is displayed in Fig. 7 (CSB, 2017, p.26).

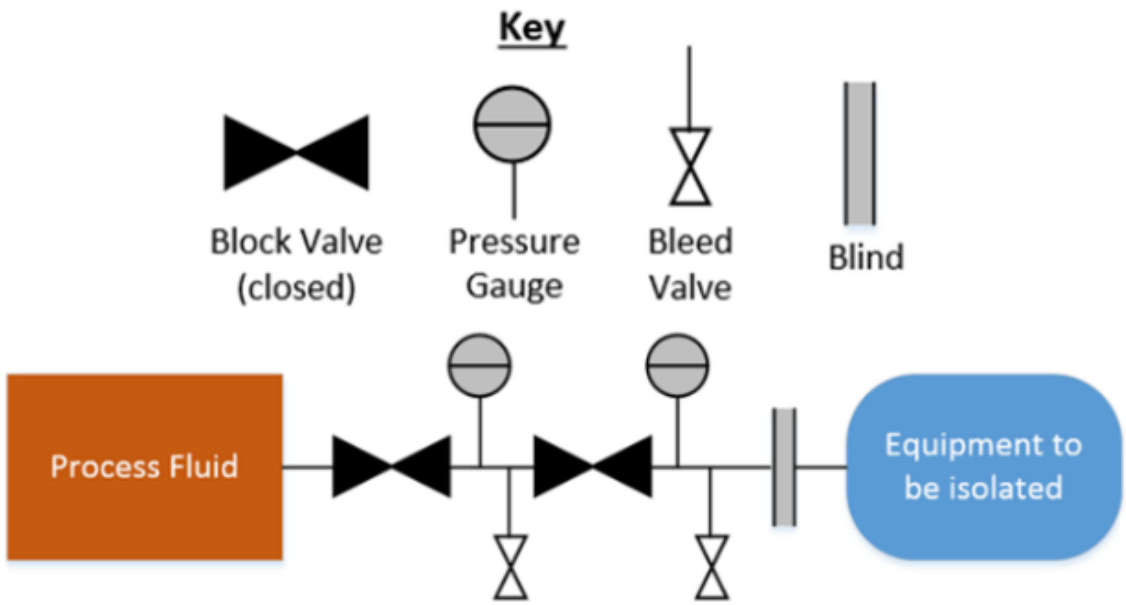

Figure 7. Diagram of the Double Block and Bleed Method with blind installed (CSB, 2017, p.26).

In 2012, a few years prior to the Torrance refinery explosion, ExxonMobil had a similar issue when the expander put the system into Safe Park mode. (CSB, 2017, p.29). The engineers working to solve the issue at the time had no desire to shut down the entire system for isolation because this would result in the loss of hydrocarbons to create gasoline. Instead, they designed and conducted a variant plan which avoided the Double Block and Bleed isolation method, and, instead, used a Single Block and Bleed method (CSB, 2017, p.29). This method eliminated the installation of a blind at the inlet entirely as seen in Fig. 8 (CSB, 2017, p.26). In order to compensate for the absent second block and inlet blind, the variance added several necessary conditions: the SCSV and RCSV needed to be fully functioning and in a closed position, steam flow to the reactor had to be greater than 2,000 pounds per hour, and a blind must be installed at the expander outlet (CSB, 2017, p.30).

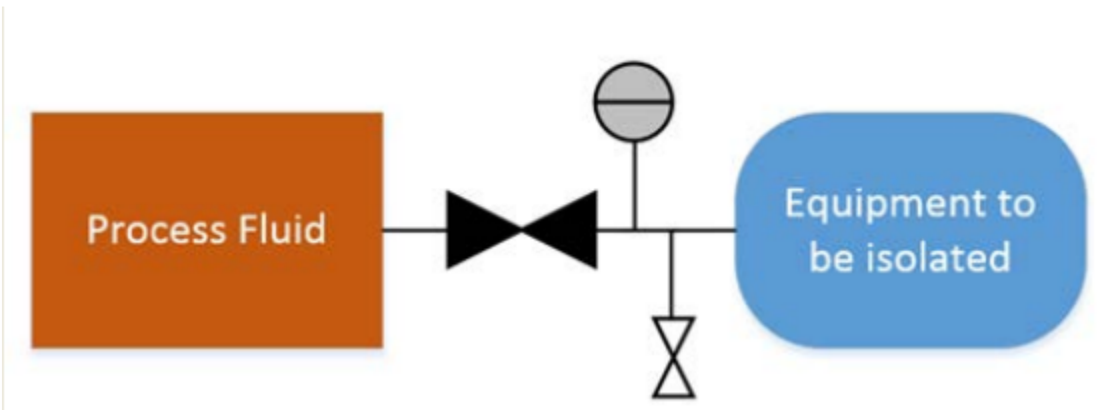

Figure 8. Diagram of the Single Block and Bleed Method used by Variance (CSB, 2017, p.26).

The Explosion

The operators started the variance by opening a flange (a protruding rim where two sections of pipe connect) located at the outlet of the expander in order to install the blind that the variance procedure required. However, once the workers opened the flange, heavy amounts of steam began to pour out of the system (CSB, 2017, p.19). The workers were unable to get past the steam and install the blind. Additionally, the escaping steam indicated an important reality: steam was back-flowing through the system, so at least one of the two essential valves was not fully sealed. At this point, the variance was fully invalidated, as it required that both the SCSV and RCSV be properly closed (CSB, 2017, p.19). It would later be discovered that the SCSV was severely eroded due to its use past its normal operation life (CSB, 2017, p.25). Without full sealing by the valve, the catalyst could not settle and buildup, eliminating one of the only two safeguards that prevented hydrocarbon backflow. This meant that the only remaining safeguard was the steam pressure driving the hydrocarbons back towards the main column.

Rather than halting the variance procedure altogether, management decided to lower the effectivity of the only remaining safeguard (CSB, 2017, p.21). Steam flow was decreased from 20,000 pounds per hour to 7,500 pounds per hour in hopes that it would lessen enough for the operators to reach the flange and install the blind (CSB, 2017, p.21). Although the minimum steam flow required by the variance was 2,000 pounds per hour, no records existed displaying how this number was found, and it proved to be far from what was actually needed (CSB, 2017, p.37-38). Shortly after reducing steam flow, hydrogen sulfide monitors began going off. Hydrogen sulfide was contained in the hydrocarbons, so this provided evidence that hydrocarbons were escaping out of the hydrocarbon side of the system (CSB, 2017, p.21). At this point, a refinery-wide evacuation occurred, and the steam was turned up to 35,000 pounds per hour. Unfortunately, the steam flow increase was ineffective, as hydrocarbons had already traveled through to the air side of the FCC unit. Eventually the vapors reached the ESP, igniting, and causing the explosion (CSB, 2017, p.22).

Ethical Analysis

Importance of Ethics and Criteria of Evaluation

Chevron Phillips' 10 Tenets of Operation will be used in the analysis of the Torrance refinery explosion. The 10 Tenets of Operation, as seen in Fig. 9 (Chevron, n.d.), provide a solid framework for analyzing ethical behavior, specifically for large refinery processes. This is because the tenets account for human error in operations in a more specific manner than a broader criteria such as the AIChE Code. Ultimately, a written code of ethics provides guidelines to keep safety paramount in importance for a company. ExxonMobil does have its own code of ethics, but Chevron Phillips' tenets provide a more relevant basis for analysis of ethical behavior for the Torrance refinery explosion specifically. Therefore, the tenets can provide a better analysis of the refinery explosion because they can identify how individual actions in the refinery were unethical. Although ExxonMobil never directly agreed to the terms of Chevron Phillips' Tenets of Operation, each of Chevron's 10 tenets are fully supported by the AIChE Code, which applies to all companies engaging in chemical processes. The main tenets of this paper, one, two, and eight, are all supported by the first code of ethics in AIChE: "Hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties" (AIChE, 2015).

Always:

1. Operate within design and environmental limits.
2. Operate in a safe and controlled condition.
3. Ensure safety devices are in place and functioning.
4. Follow safe work practices and procedures.
5. Meet or exceed customer's requirements.
6. Maintain integrity of dedicated systems.
7. Comply with all applicable rules and regulations.
8. Address abnormal conditions.
9. Follow written procedures for high-risk or unusual situations.
10. Involve the right people in decisions that affect procedures and equipment.

Figure 9. Chevron Phillips 10 Tenets of Operation (Chevron, n.d.).

The Unethical Actions of ExxonMobil

First, ExxonMobil failed to act ethically by using out of date equipment that had deteriorated in quality. By using both out of date and generally unsafe equipment in the Torrance refinery, ExxonMobil violated Chevron Phillips' First Tenet of Operation: "Always operate within design and environmental limits"(Chevron, n.d). Post-incident investigations showed that the Torrance refinery had an extremely eroded SCSV, preventing the catalyst buildup from playing its role as a physical barrier during Safe Park mode. After analyzing the SCSV erosion, it was apparent that the unit was in its sixth year of operation, two years past ExxonMobil's expiration date for the piece (CSB, 2017, p.25). Additionally, the pipes surrounding the expander were never designed in a way for the expander to be isolated (CSB, 2017, p.29). Unfortunately, this did not stop the workers of the refinery from attempting to isolate the expander to avoid system shutdown. A lack of attention towards operating equipment within defined safety limits is an ethical failure according the Tenets of Operation (Chevron, n.d).

ExxonMobil acted unethically a second time by forcing an under-researched "Variance" procedure that allowed fewer safety precautions, in hopes of increasing efficiency (CSB, 2017, p.25). This is a violation of Chevron Phillips' 8th Tenet of Operation: "Always address abnormal conditions" (Chevron, n.d). Although some abnormal conditions were technically addressed, they were addressed poorly and quickly, and safety was treated as anything but paramount. ExxonMobil addressed the abnormal expander issues with a variant procedure to prevent the shutdown of the refinery. If any personnel had performed a simple safety analysis, the danger of a single block and bleed isolation method would have quickly surfaced. Chiefly, they would have discovered that the minimum steam flow called for by the variance was extremely low. It is likely that prioritizing the profit of the refinery over the safety of the people in Torrance was not a conscious decision; however, the decision to lazily address abnormal conditions to keep the expander operating was likely a conscious decision that had harsh safety consequences.

Finally, ExxonMobil failed to act ethically a third time by ignoring clear signs of danger when conducting the isolation maintenance. This is a violation of Chevron Phillips' 2nd Tenet of Operation: "Always operate in a safe and controlled condition" (Chevron, n.d). When the flange was opened in order for the blind to be installed, steam came pouring out of the opened flange. This was a clear indication to the workers of the refinery that the SCSV had eroded enough to negate any physical catalyst barrier, and the true steam flow was unrelated to what indicators had read. At this point the flange should have been closed, steam should have been turned up, and variance should have been abandoned. Instead, the team decided to reduce the flow of steam in order to have greater access to the flange (CSB, 2017, p.20). Further worsening the assessment of the situation, the operators did not begin evacuation for nearly thirty minutes after clear signs of hydrocarbon backflow had been found. Around 8:10 AM, a supervisor working near the FCC was alerted by his hydrogen sulfide detector that unnatural levels of this chemical were in the air. This indicated that the gasses from the hydrocarbon side of the FCC were leaking through the air side, as hydrogen sulfide was contained in the FCC. It was not until 33 minutes later when evacuation of the area surrounding the FCC began (CSB, 2017, p.21-22). The delay in evacuation of the refinery workers ultimately created an even greater safety hazard, suggesting that their safety was not the top priority.

Conclusion

ExxonMobil acted unethically by prioritizing profit over the safety of the workers at the Torrance refinery. As one of the largest companies in one of the most profitable industries in the world, replacing out of date equipment is a negligible investment. Furthermore, shutting down a single unit in ExxonMobil's *second smallest refinery* would have been a very insignificant cost to ensure the safety of their workers and the people living in the surrounding Torrance community. However, because safety was second to profit, the company did not replace the equipment until irreversible damage was observed. With 70,000 employees, asking a small team to take time and perform a thorough safety analysis on a mysterious variance procedure would not be a mighty feat (CSB, 2017, p.57). Nevertheless, ExxonMobil decided, instead, to put full trust in a less safe variance procedure that had only been used once before. This irrational decision provides evidence that ExxonMobil's focus was on producing gasoline for profit, not ensuring the safety of the refinery and surrounding environment. Finally, after placing themselves in an unsafe situation, ExxonMobil received one more chance to avoid major consequences. The steam leak of the newly opened flange clearly indicated to the operators and managers that the safety precautions they relied on had failed. Yet, ExxonMobil pressed on and continued to neglect safety, evacuating people only minutes before the explosion.

Considering the repeated, clear signs of danger ignored by the workers of the Torrance refinery, several questions arise: What is the culture of ExxonMobil such that employees are afraid to halt production for safety? Has industry competition reached a level such that ExxonMobil feels the need to promote such a culture? What practical steps can be taken in order to prevent such work cultures from forming? These are the types of questions that must be answered for progress to be made within engineering ethics.

Abiding by Chevron Phillips' 10 Tenets of Operation most likely would have maximized not only safety, but profit as well for ExxonMobil's Torrance refinery. The reality is that people get hurt when ethical codes are not strictly observed and enforced (Davis, 1991). In this case, four contractors were injured in the explosion. Additionally, toxic catalyst dust was released and spread over the surrounding Torrance community, causing unknown long-term damages to people and the surrounding environment. Less intuitive, however, is the reality that ethics often saves more money long-term than cutting corners. ExxonMobil was fined $566,000 by OSHA (Occupational Safety and Health Administration) after the explosion for breaking several regulations related to the unethical actions stated earlier (Groom, 2015). The destruction of the FCC and surrounding units led to unmeasured loss of profits as repairs took place. Additionally, ExxonMobil later sold the entire plant, partially due to public pressures after the incident (Groom, 2015). The company’s stock plummeted, and California drivers cumulatively paid around $2.4 billion extra as gas prices spiked, marring the company’s public image (Groom, 2015). Considering the harm to workers, the public, and the company as an entity, everyone benefits if Exxon abides by the 10 Tenets of Operation in the future.

Word Count: 3942

References

American Institute of Chemical Engineers (AIChE). (2015, November). Code of Ethics. Retrieved from https://www.aiche.org/about/code-ethics

This is a generally accepted code of ethics across the chemical engineering industry. The AIChE code first gives several broad goals of every chemical engineer, then expands upon how to achieve these goals using eleven guiding principles. These guiding principles can be used to validate Chevron Phillips' Tenets.

California Department of Industrial Relations (DIR). (2015, August 13). Cal/OSHA Cites ExxonMobil $566,600. Retrieved from https://www.dir.ca.gov/DIRNews/2015/2015-76.pdf-/

In this brief article the state of California tells of which particular agencies involved themselves in cleaning the mess ExxonMobil created. OSHA's role in the investigation and discipline following the accident is highlighted. The article also provides specific regulations broken and assists in analyzing the incident from a legal standpoint.

Chevron Phillips. (n.d.). Operational Excellence. Retrieved from https://www.chevron.com/-/media/chevron/PDF-Reports/About/about-operational-excellence.pdf

This is Chevron Phillips ten tenets of operation. These tenets would have been especially helpful for ExxonMobil in this situation, as they highlight fulling addressing safe work practices, procedures, and abnormal conditions. These were the key issues of the Torrance refinery explosion.

Davis, M. (1991). Thinking like an engineer: The place of a code of ethics in the practice of a profession. *Philosophy & Public Affairs*, *20*(2), pp. 150-167.

In Thinking Like an Engineer, Michael Davis makes an argument for the necessity of ethics in engineering. Using this article, one can discover disparities between ExxonMobil's and Davis's thought-process and identify where thinking more like Davis may have prevented the accident.

Groom, N. (2015, February 18). Explosion at Exxon Mobil refinery in Torrance. Retrieved from https://www.reuters.com/article/us-refinery-blast-exxon/explosion-at-exxon-mobil-refinery-in-torrance-california-injures-four-idUSKBN0LM1VR20150218

This review of the explosion provides a loose timeline of the incident as well as the impact it had on ExxonMobil as a corporation. The article tells of many long-term repercussions, including decrease in market share value and shut-down of the plant for repairs. These consequences can be provided as further motivation for corporations to follow a code of ethics.

U.S Chemical Safety and Hazard Investigation Board (CSB). (2017, May 3). *ExxonMobil Refinery Explosion* (Report No. 2015-02-I-CA). Retrieved from https://www.csb.gov/exxonmobil-refinery-explosion-/

This comprehensive study provides detailed information on where ExxonMobil failed to follow regulations. The study also provides technical information on what happened with specific chemicals and equipment pieces to produce the actual explosion. This study is the key to details of the plant, the people, the incident, and the aftermath.